The Six Elements: Visions of a Complex Universe

There are rosebushes in front of my house, and sometimes I step outside to stand among them, enjoying the look and scent of their blooms. I was raised in the city, and it still surprises me to see growing things spring from the earth. That may be why, as I pick up a handful of earth, I think how remarkable it is that its matter-of-fact grittiness leads to the intricate beauty of roses. It is natural for one then to think of Earth on a larger scale as one of the Four Elements of antiquity.

Earth, Air, Fire and Water: All relate to growing things, and furthermore to life on our planet, to the structure of the planet itself, ultimately to all nature. The meaning of Earth, for instance, extends far beyond that of the rough, pragmatic material I can hold in my hand; it is the brute bulk of our world, expressed in massive geological formations, the substance of other worlds, the dense interiors of dead stars. It is precious minerals, useful ores from deep mines and the exquisitely refined gemstones and solid materials we make from those raw substances.

With that last realization, I see that the archaic idea of Earth is still significant. Physicists study solids in laboratories, where it is easy to forget that they come from nature. It is at first startling, and then illuminating, to re-connect them to their origin, the element Earth. Water, Air and Fire also have meaning in modern science. Water and Air correspond to liquids and gases, the other two great categories of matter; Fire can be interpreted as light, an energy that has always filled the universe, and as flame and heat.

Early philosophers considered two more categories: Void, the emptiness that contains matter, and Quintessence, a substance that forms the distant cosmos. These too have modern counterparts. Void is the vacuum beyond our atmosphere; as what physicists call the vacuum state, it is where the universe began. Quintessence corresponds to "dark matter"—the invisible material that is unlike anything on this planet and that makes up at least nine-tenths of the cosmos—and to "dark energy," the equally mysterious antigravity that is accelerating the expansion of the universe.

These ancient groupings are counterweights to the reductive style of modern science, which emphasizes nature's smallest units. This approach is highly successful, giving deep insights, for example, into the quantum nature of reality and the significance of DNA. However, it does not span the full picture that began 13 billion years ago with the Big Bang. The Six Elements—the Four plus Quintessence and Void—are universal categories that engender coherent visions of the physical universe, visions with artistic as well as scientific meaning and the power to bridge those areas.

Two Greek thinkers in the 6th century B.C.E. first conceived the natural Elements. To Anaximenes, everything was made of Air. Rarefied, it became Fire, which formed the Sun; condensed, it became Water and Earth. Thales took Water as primary; "All things are water," he wrote. A century later, the philosopher Heraclitus thought Fire was the basic substance.

A universe made from a single substance is elegantly simple, but a better model for the world's diversity came from the Greek philosopher Empedocles, born in Sicily around 495 B.C.E. A figure of mystical power, he was said to be able to raise the dead and later to have thrown himself into Mount Etna's crater to join the gods. His great accomplishment is the idea that Earth, Air, Fire and Water form what lies around us, brought together or kept apart by Love and Strife. This brilliant scheme is broad enough to describe great swatches of the

cosmos, yet sufficiently articulated to explain much. Bone, for instance, is Earth and Water blended together by the application of Fire, all in the proportion 1:1:2. Human vision occurs as Water modifies Fire; that is, the vitreous humor in the eye affects the visual ray, which in Empedocles' time was thought to come from the eye.

For all the power of the Four Elements, Aristotle later asked, How could they account for the perfection of the heavens? Accordingly he added a noble and incorruptible Fifth Element. Translated as *quinta essentia* in the Latin of Medieval scholars, its name lives on in the word "quintessence." The ordinary world was made of Earth, Air, Fire and Water; Quintessence made the distant cosmos.

One more essential category came from the Greek thinker Leucippus and his student Democritus, who in the 5th century B.C.E. postulated that everything is made of irreducible atoms operating within the arena of space. "Nothing exists except atoms and empty space," wrote Democritus; "everything else is opinion." Or, as the Roman poet Lucretius put it 300 years later in his *De Rerum Natura* (On the Nature of Things):

> The nature of everything is dual-matter
> And void; or particles and space, wherein
> The former rest or move.

Void is the sixth category—seemingly colorless and inconsequential, but having, as with the "zero" in algebra, enormous consequences.

Today science sees the world differently. An "element" is not one of the Four or Six, but one of the hundred-odd types of atoms—hydrogen, oxygen, iron and so on. Water is not elemental but a compound of hydrogen and oxygen. Atoms are not irreducible but made of electrons and quarks. Living things are made of cells, and cells have their own smaller components. This reductionism is essential to modern science, but the Elements provide a more unified comprehension of the universe.

Think again of the roses near my home. The plant life they represent underlies all earthly existence, including our own. A growing plant is supported by Earth, which also stands for any solid material. The plant needs carbon dioxide and nitrogen, and we ourselves need oxygen—which, along with other gases, forms our atmosphere, a complex form of Air. Water, H_2O, is also essential for life and covers nearly three-quarters of our planet. The Element Water also appears as sluggish petroleum and heavy, glinting mercury. Fire, as light from the Sun, floods our world. It too is essential, and life has evolved in response to it. If Fire is taken as flame and heat, it is also sunlight stored in coal, wood, oil and gas and freed by burning.

Void, however, exists on our planet only in human-made vacuums, and Quintessence not at all. Both come into their own in the modern view that the universe began in the vacuum state and contains dark energy and dark matter. Aristotle was partly right in thinking that the celestial sphere is made of a different kind of material; still, the Element Earth appears in every planet and moon in our solar system, and in burned-out stars beyond it. Air is the hot chemical brew that is the atmosphere of Venus and the hydrogen widespread in space. Fire, taken as light, is the natural inhabitant of the cosmos and along with Void, the oldest. Created directly in the Big Bang, light's remnants still flash through the universe while new light glows from the stars.

Water, however, taken as Element or as the particular liquid H_2O, was once thought to be limited to our own planet. Now we know that H_2O has existed on Mars, that oceans of it may lie beneath a layer of ice on Jupiter's moon Europa and that petroleum-like lakes can be found on Saturn's moon Titan. Nevertheless, Water has the smallest cosmic presence of the original Four; contrary to Thales' philosophy, the universe is mostly dry.

Empedocles combined four Elements in varied proportions to form the world. Anaximenes envisioned a different evolution, in which Air thickened or thinned to form the parts of reality. Remarkably, both processes operate in the universe. There are countless examples of mixtures of Elements: For instance, ocean foam, made of Water and Air. Like Empedocles' Love and Strife, matter attracts or repels matter through four forces: the "strong" and "weak" forces within atomic nuclei; the electromagnetic force, which holds atoms and molecules together; and gravity, which works on every kind of matter.

Rarefaction and condensation occur as well. Soon after the Big Bang the Element Air first appeared as hydrogen gas. Under gravity, a cloud of hydrogen would become denser and hotter, until hydrogen nuclei would fuse into helium at a temperature of millions of degrees. That changed matter into energy, according to Einstein's relation $E = mc^2$, to form a glowing star. Later, helium nuclei would fuse into carbon. As the hydrogen became depleted and the star cooled and died, gravity would compress the carbon into a small, white-hot "white dwarf" of formidable density, weighing a ton per teaspoon. To Anaximenes, this conversion of hydrogen into surpassingly solid carbon would simply be Air condensing into Earth.

Condensation also formed our solar system. Five billion years ago, in a nebula made of hydrogen and dust, gravity accreted dust grains into pebbles, rocks and finally planets. Mercury, Venus, Earth and Mars have hot cores made of solid and liquid iron, surrounded by molten rock and a solid crust. These bodies also developed atmospheres and on Mars and on Earth, oceans. The other planets have rocky cores encased in solid, liquid and gaseous hydrogen, helium and other substances. In short, the planets condensed from Air and Earth into Earth, Air, Fire and Water.

As an example of rarefaction, dense, massive stars can explode in a supernova, an inconceivable outpouring of energy like that from a trillion stars. Chinese astronomers observed one in 1054 A.D. It tore a nameless star into rags of gas and dust, an enormous cloud of debris 6,000 light years away visible today as the Crab Nebula, its claw-like tendrils still spreading rapidly into space. The Crab, too, might please Anaximenes, for it is Earth transmuted into Air.

Some supernovas leave behind a hyper-dense core made of tightly packed neutrons. Its own ferocious gravity can squeeze the core down to a mathematical point—a distortion in space-time through which ordinary matter disappears and from which light cannot escape. This is a black hole, predicted by Einstein's General Relativity and recently detected at the center of our own galaxy. In Elemental terms, a black hole is where Earth distorts Void and captures Fire, as matter at extreme density twists space-time to trap light.

Although science now explains more than the early Greeks could, the Elements point to some remaining puzzles. For Water, we do not fully grasp how the molecules in liquids link together and how liquids flow in seemingly unpredictable turbulent swirls. This is also a great problem in gases, that is, Elemental Air. We understand the Element Earth in hard crystalline forms, as in salt or copper, but not so well in soft amorphous form, as in clay.

Of the Four, however, Fire as light is the most mysterious, perhaps because it is the least tangible. It is made of particle-like photons but also acts like a wave, in that paradoxical duality that has long puzzled physicists. Photons also undergo what Einstein called a "spooky" interaction: quantum entanglement. For reasons unknown, two photons can apparently communicate instantaneously no matter how far apart, as has been proven for distances near 100 miles. The ancient Greek thinkers struggled mightily with the nature of light, and that struggle still continues.

We have more evidence of Void and Quintessence than the Greeks did but do not fully understand them either. Void as vacuum was first discerned in the 1640s by Galileo's former laboratory assistant Evangelista Torricelli in his mercury barometers. Now we create vacuum at will and explore the vacuum of space. What is difficult to grasp is that random quantum fluctuations in nothingness led to the Big Bang, yet that seems to be the origin of the Universe.

Quintessence became scientific in 1933, when the astronomer Fritz Zwicky postulated the existence of invisible or dark matter to explain how galaxies rotate in space. Dark energy was discovered in 1998, when astronomers found the universe to be expanding faster than predicted due to a universal repulsion that counteracts gravity. However, we do not yet know much more about these facets of Quintessence than Aristotle did.

In addition to providing a structure for scientific thought, the organizing and metaphorical power of the Elements has inspired artists in different eras. Sometimes the Elements appear allegorically, as in Nicolas Poussin's painting *Cephalus and Aurora* (1627–1630). It shows Cephalus rejecting the love of Aurora, goddess of the dawn, out of loyalty to his wife. The scene is embellished by the Four Elements, represented by the Earth goddess Gaia; the winged horse Pegasus, for Air; the sun god Apollo, for Fire; and the sea god Oceanus, for Water.

Other artists portrayed the Elements realistically based on observation of the world, the common basis of science and art. Leonardo da Vinci often rendered Water in motion, as in

one painting of his *Deluge* series (c. 1510) that illustrates the turmoil caused by rocks crashing into water. Later that century, Caravaggio painted his famously intense lighting effects. They influenced Georges de La Tour, a close observer of Fire. His *St. Sebastian Attended by St. Irene* (c. 1649) shows the flame from a torch as if the artist has frozen its dynamic twisting forms with a camera. Void was expressed by the 18th-century English painter Joseph Wright. His *Experiment on a Bird in the Air Pump* (1768) shows a lecturer demonstrating vacuum by pumping the air from a chamber containing a white cockatoo that is about to expire.

Some artists use the Elements directly. Ground up and mixed with a carrier, Earth has been a source of color pigments since the prehistoric cave-painters. Now it is the medium in Robert Smithson's massive earthwork *Spiral Jetty* (1970) on Utah's Great Salt Lake. Air and Water also appear. One of Marcel Duchamp's ready-mades from 1919 is a small glass ampoule filled with Parisian air. Decades later, in his installation *Tramway* (1976), the radical German artist Joseph Beuys filled an iron pipe with water from beneath the work's site in Venice. Other artists exploit moving water. Fire has flourished in art at least since 1963, when Dan Flavin made glowing sculptures from fluorescent lamps. Later, James Turrell filled space with seemingly tangible light. Void appears in *Development of a Bottle in Space* (1912) by the Futurist Umberto Boccioni, which shows solid matter flowing into space that flows back into solid matter; and in Aleksandr Archipenko's *Walking Woman* (1912) and *Woman Combing Her Hair* (1915), which use open areas to represent a woman's face and body within solid bronze forms.

The Belgian surrealist René Magritte created his own Elements. In *The Six Elements* (1928), panels set in an irregular frame show fire; sky and clouds; deep woods; a naked woman's torso; the facade of a house; and bells from a horse's harness floating over a lead curtain, a recurrent theme for Magritte. These scenes appear in other works, such as one version of *The Empty Mask* (1928), except that there a paper cutout replaces the torso. In each painting only two or three of the six fit into the original Four, making the remaining ones strangely evocative.

Another version of *The Empty Mask* (1928) shows four elements, each denoted by a word or phrase rather than an image. Magritte's characteristic use of words in his art presents an ingenious way to sidestep the difficulty of portraying "Void" by simply painting the word "vide" inside a frame. But whatever his choices for the Elements and their representations, what is important is the act of choosing; as the noted art critic and historian A.M. Hammacher has put it, by his selection Magritte "regroup[s] the isolated elements of life . . . [he] dissolves the untidy picture of the ordinary world into a number of vital factors" [1].

This analysis of an artist's thinking aptly describes the continuing power of the categories defined by those Greek thinkers to impose sensible order on the world and our understanding of it. The Elements, whether the Four or the Six, have a way of uniting art and science—and of encouraging us to see distant worlds in the petals of a rose.

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Reference

1. A.M. Hammacher, *René Magritte* (Harry N. Abrams, New York, 1995), p. 98.